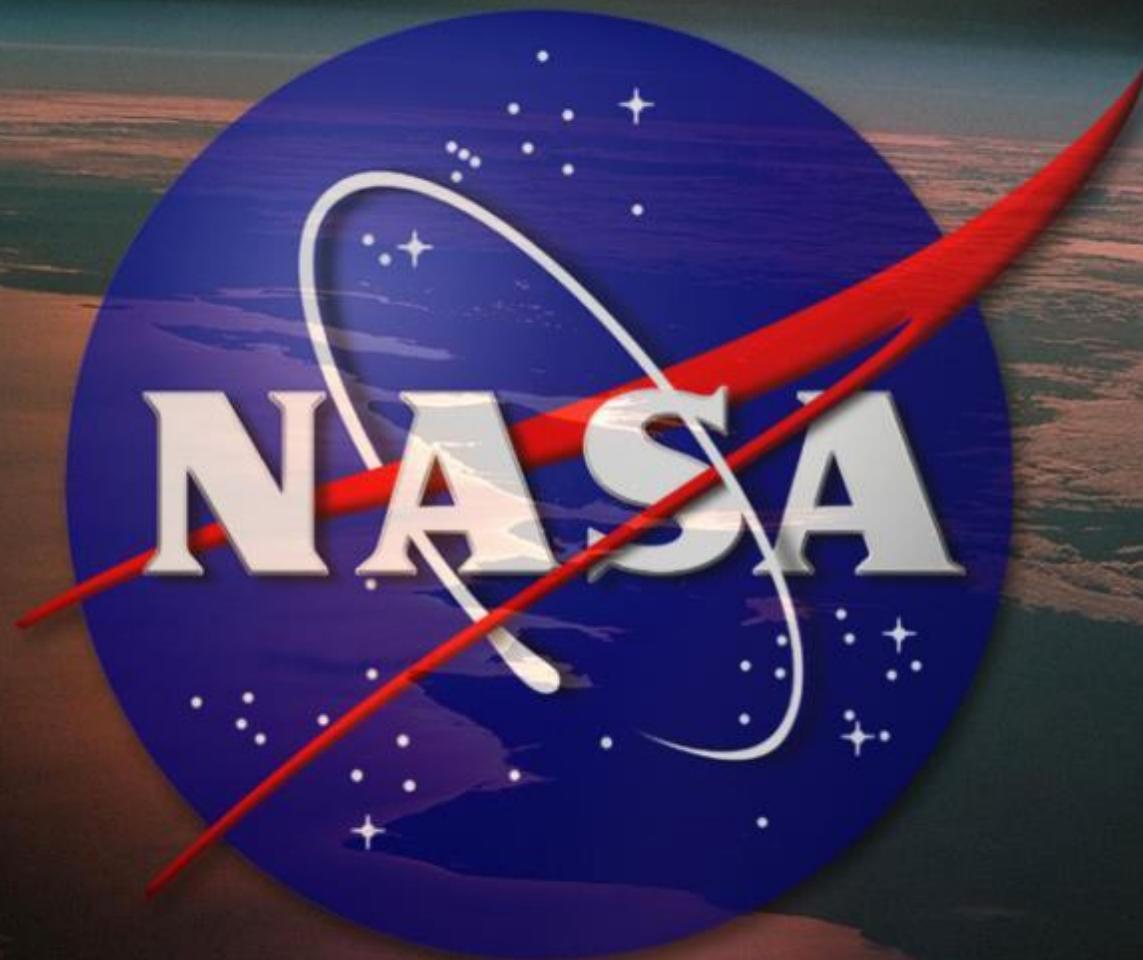


# Welcome to JSC



Liftoff Summer Institute July 2017 Presentation V2



# Where Do We Go From Here?

Tim Hall

NASA Johnson Space Center

June 2017

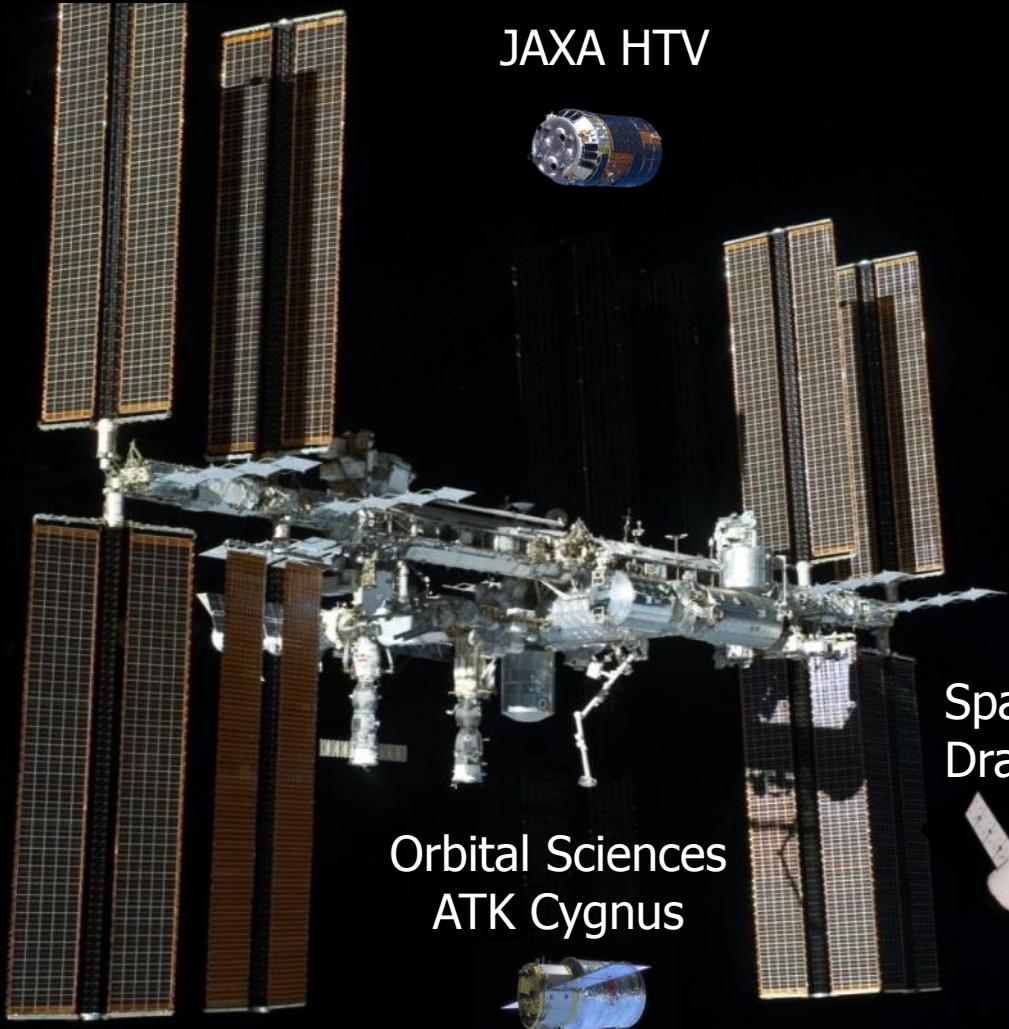


# First, What's Going On Now At NASA Today?

# Human Spaceflight...



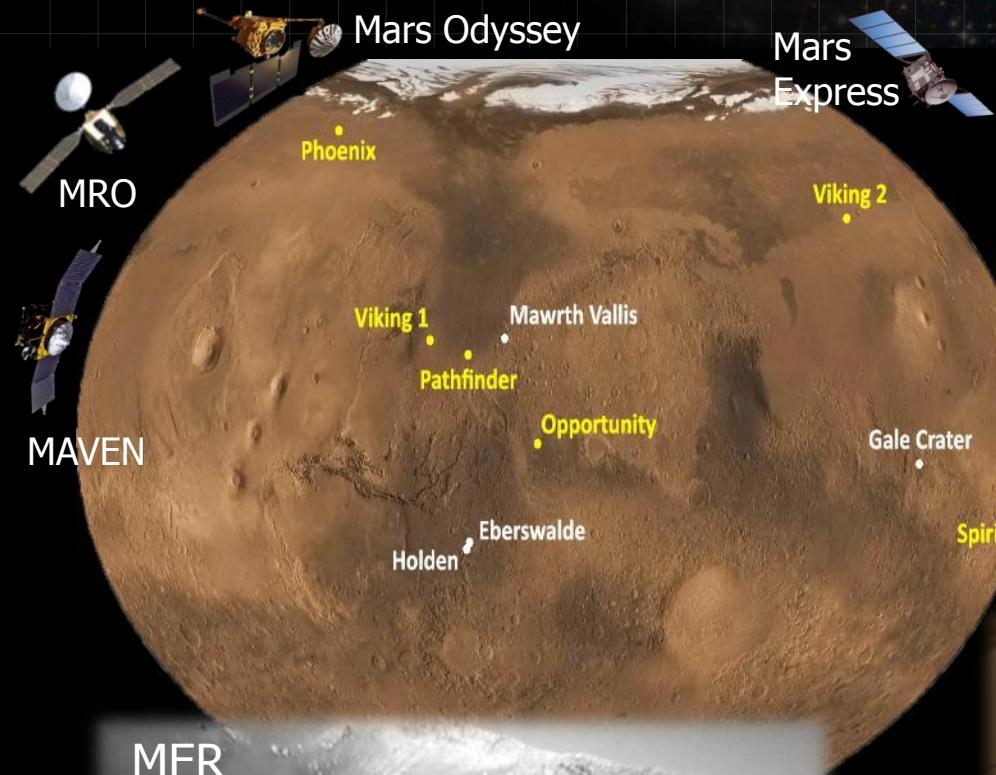
Expedition 52



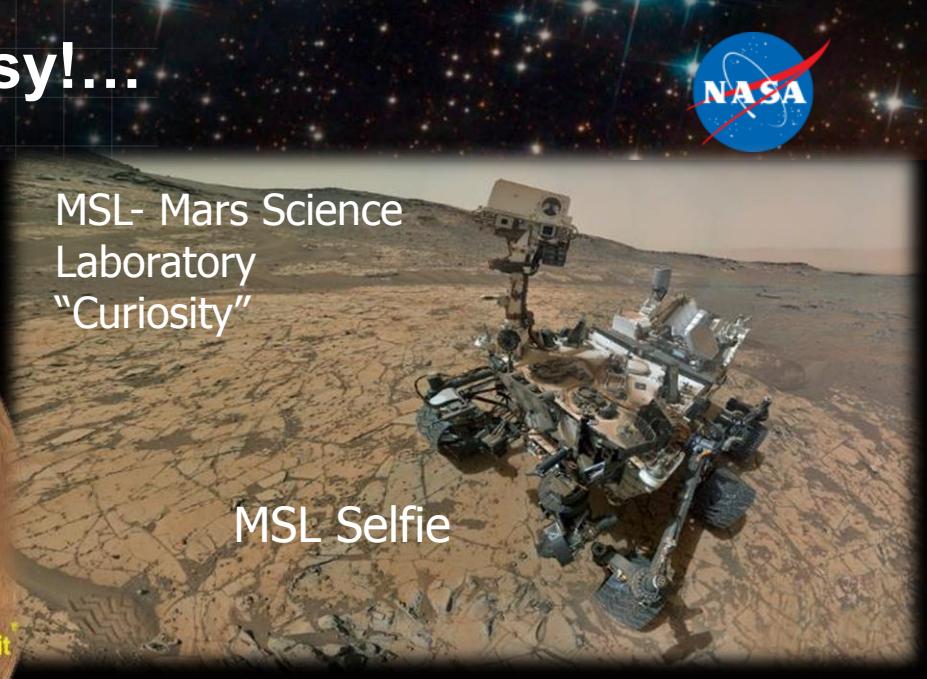
Expedition 53



# Planetary Missions, Mars is busy!...



MER  
Mars Exploration  
Rover  
“Opportunity”

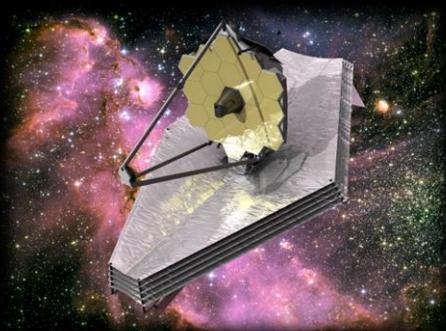


# Many, many other cool missions...

Just a few to mention...



**Cyclone Global Navigation Satellite System (CYGNSS)**  
is a space-based multi satellite system developed to improve hurricane forecasting



James Webb Telescope  
Launch in 2019

Juno

Arrived at Jupiter July 2016



**Hubble**  
Still researching origins of the universe



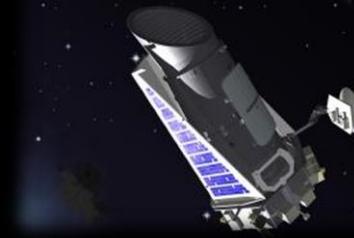
Eyes on the Solar System  
<http://eyes.nasa.gov/>

Kepler

Planet Count

Confirmed Planets: 977

Planet Candidates: 4,234



**Voyager 1**

Has left the building...

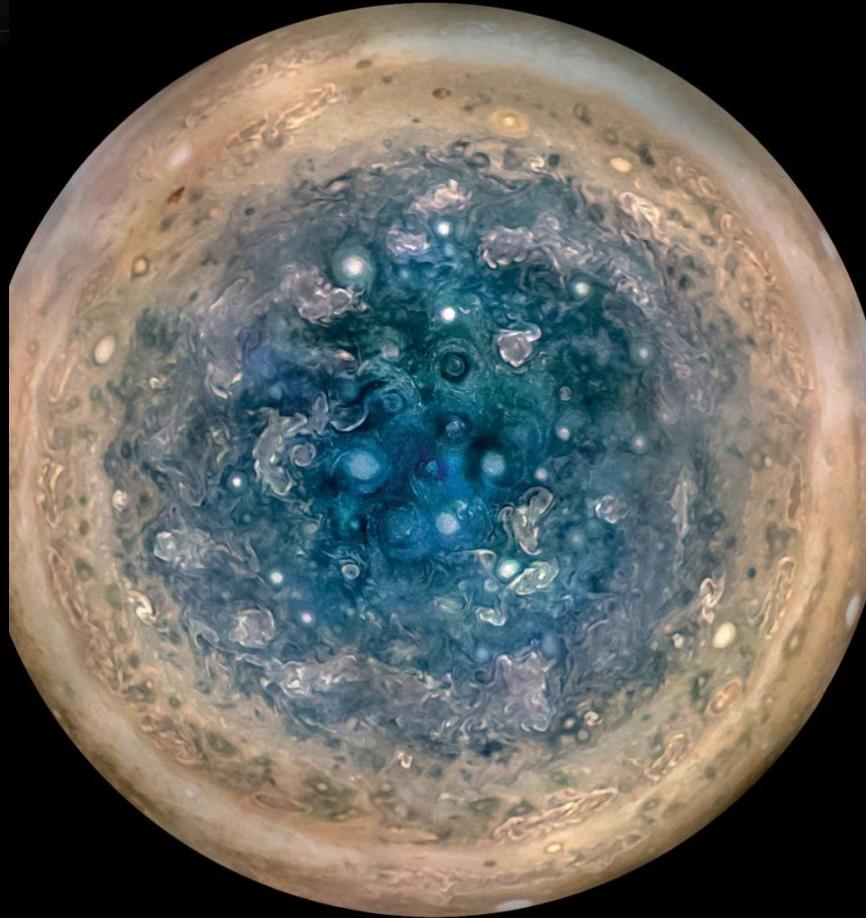
Traveling interstellar space



# Jupiter – JUNO



- Juno is a NASA space probe orbiting the planet Jupiter.
  - It is operated by NASA's Jet Propulsion Laboratory. The spacecraft was launched from Cape Canaveral Air Force Station on August 5, 2011,
  - Juno entered a polar orbit of Jupiter on July 5, 2016 to begin a scientific investigation of the planet.
  - After completing its mission, Juno will be intentionally deorbited into Jupiter's atmosphere.[8]
- Juno's mission is to measure Jupiter's composition, gravity field, magnetic field, and polar magnetosphere.
  - It will also search for clues about how the planet formed, including whether it has a rocky core, the amount of water present within the deep atmosphere, mass distribution, and its deep winds, which can reach speeds of 618 kilometers per hour (384 mph)



"It's snowing on Jupiter, and we're seeing how it works," Juno principal investigator Scott Bolton, of the Southwest Research Institute in San Antonio

Zoomed-in view of a photo taken by NASA's Juno probe on May 19, 2017, showing clouds of water ice and/or ammonia ice high up in Jupiter's atmosphere in the south tropical zone.



# Jupiter – Juno



- This enhanced-color image of Jupiter's bands of light and dark clouds was created by citizen scientists Gerald Eichstädt and Seán Doran using data from the JunoCam imager on NASA's Juno spacecraft.
- Three of the white oval storms known as the "String of Pearls" are visible near the top of the image. Each of the alternating light and dark atmospheric bands in this image is wider than Earth, and each rages around Jupiter at hundreds of miles (kilometers) per hour. The lighter areas are regions where gas is rising, and the darker bands are regions where gas is sinking.
- Juno acquired the image on May 19, 2017, at 11:30 a.m. PST (2:30 p.m. EST) from an altitude of about 20,800 miles (33,400 kilometers) above Jupiter's cloud tops.

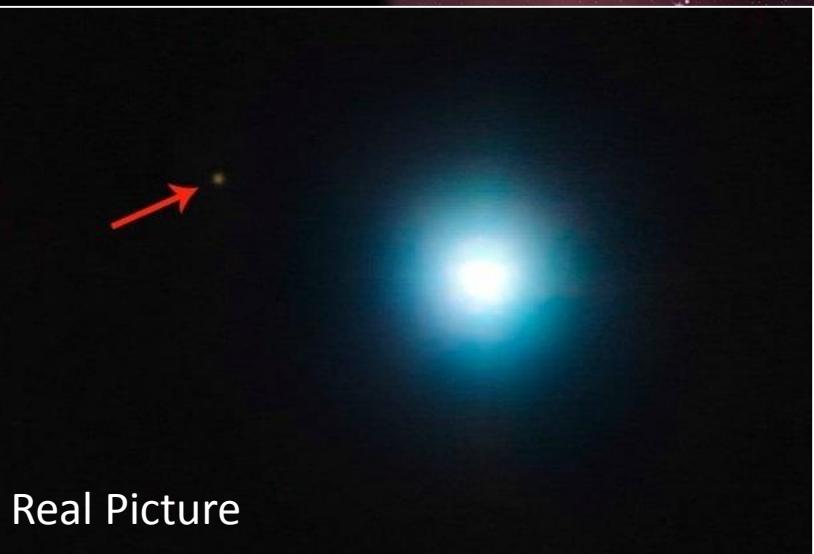


# Exoplanets



## NASA Finds 219 Possible Planets, Including 10 'Earths'

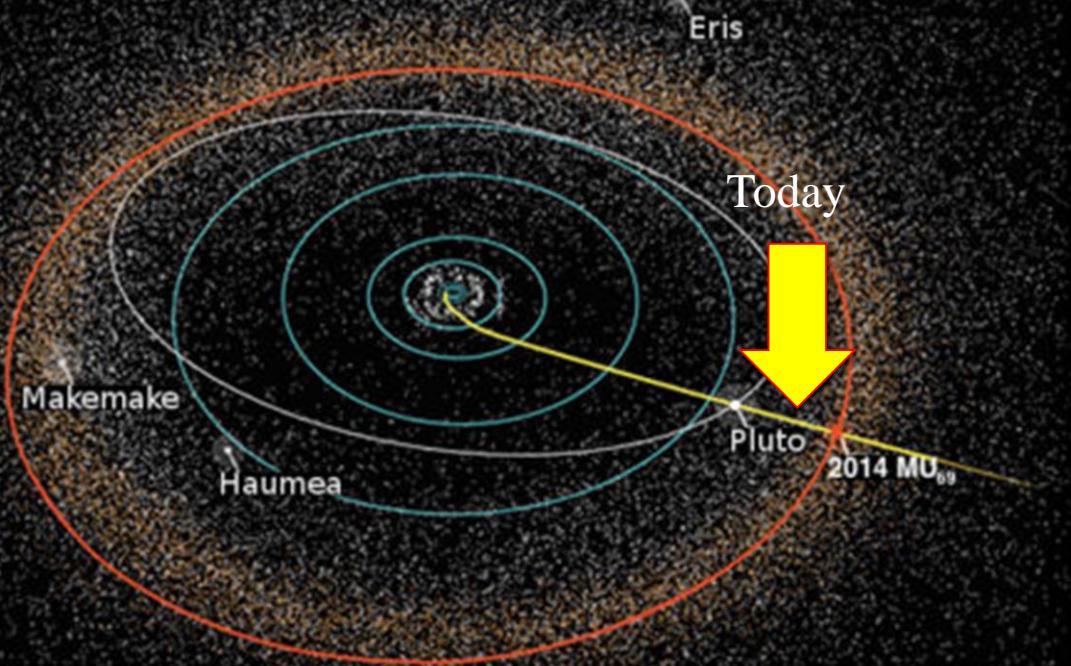
NASA's Kepler space telescope team has released a mission catalog of planet candidates that introduces 219 new candidates, 10 of which are near-Earth size and orbiting in their star's habitable zone, which is the range of distance from a star where liquid water could pool on the surface of a rocky planet.?



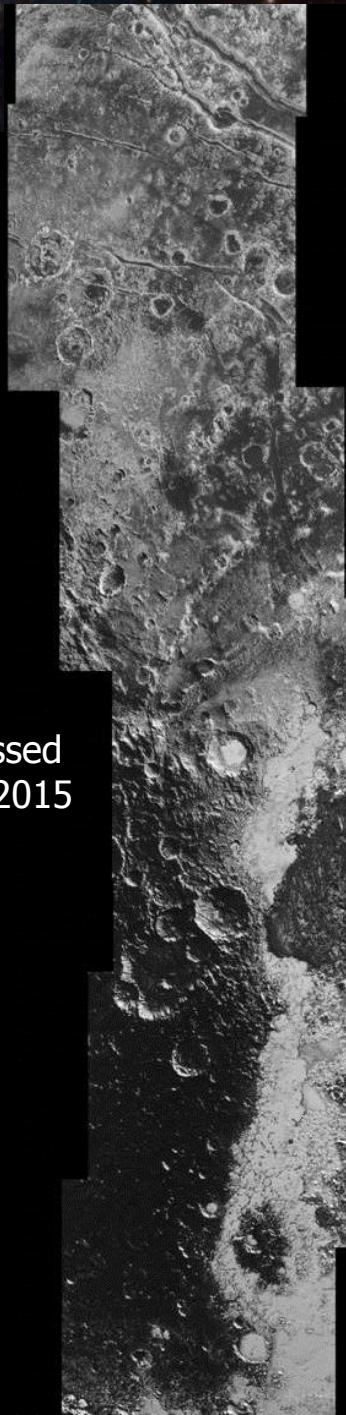
Astronomers have managed to capture an amazingly clear image of CVSO 30c - a potential exoplanet orbiting a distant star named CVSO 30, that lies some 1,200 light-years away.

# New Horizons @ Pluto!

- New from NASA's New Horizons:
  - The Spacecraft just passed half way to its next target MU69 in January of 2019



NASA's New  
Horizons  
spacecraft passed  
Pluto in July 2015



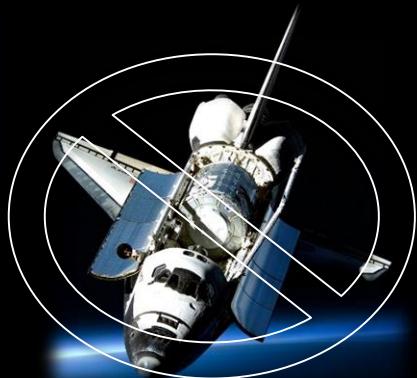


Human Space Flight Vehicles and  
Plans for Exploration

# Human Space Flight “Vehicles” for ISS

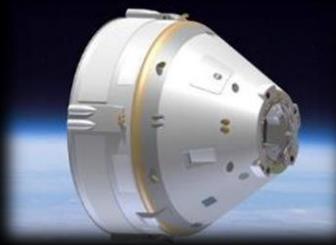


Russian Soyuz



US Space Shuttle

Future US  
Commercial Crew  
Capsules



Boeing CST-100  
Starliner



SpaceX Dragon  
Capsule

- NOTE: ISS Also has Cargo Vehicles for ISS (no human rating)

## Commercial Resupply Vehicles

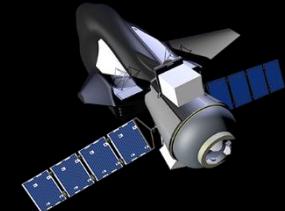
SpaceX  
Dragon  
Cargo



Orbital Sciences  
ATK Cygnus



Sierra Nevada  
Dream Chaser  
Cargo  
(2019)



## International Partner Vehicles

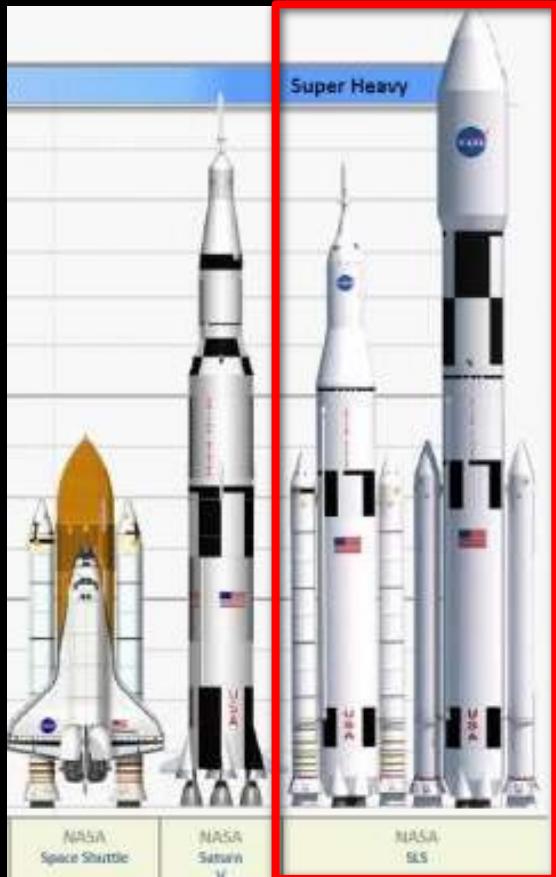
JAXA Space  
Agency  
HTV



# Human Space Flight “Vehicles” for Exploration



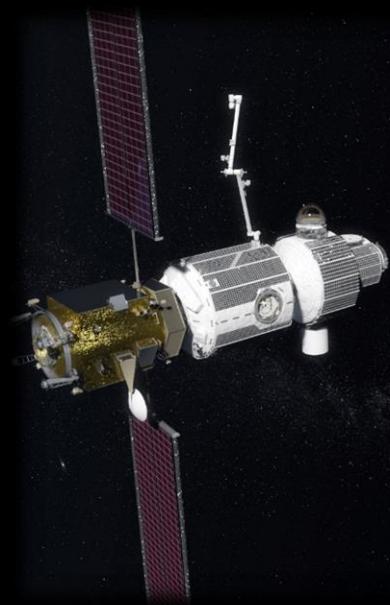
- Exploration



Orion & Service Module



Possible Deep Space  
Gateway  
(Habitat and Propulsion  
Module and Airlock)

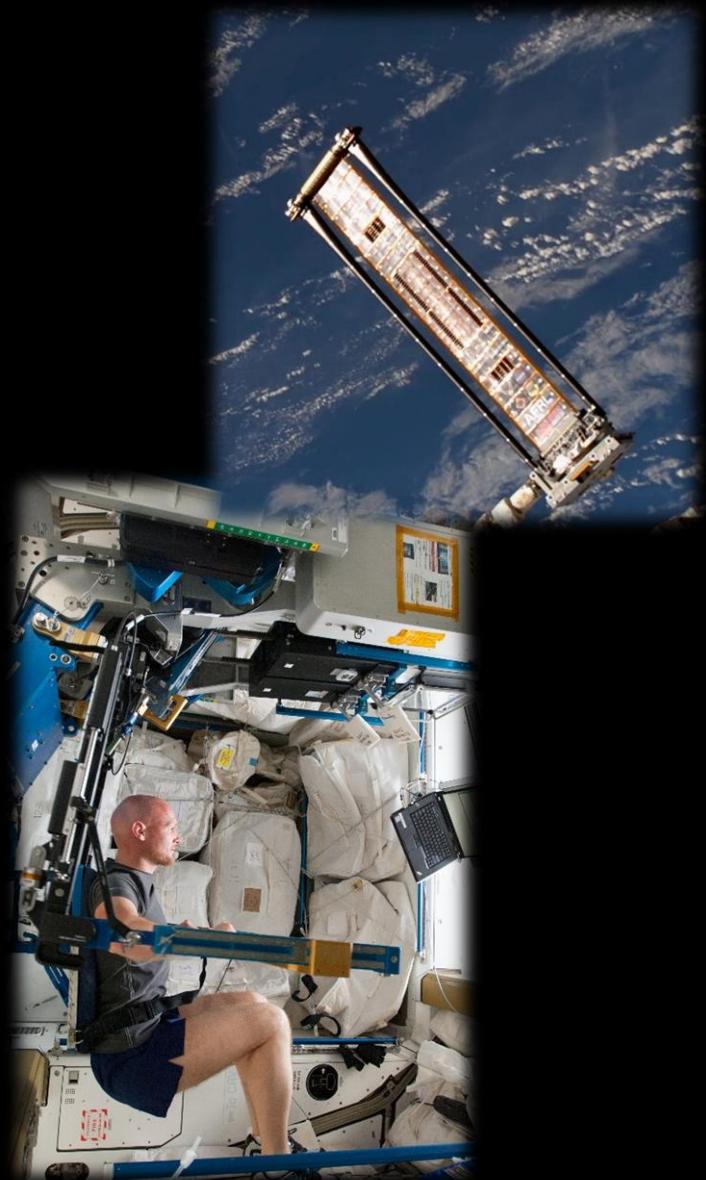


SLS – Space Launch System  
Heavy Lift Vehicle

# NASA Plans to use ISS as Test Bed for Exploration



- Utilize ISS to test out exploration technologies
- These include:
  - Closed Loop Environmental Systems
  - Power Systems
  - Materials for use in deep space environments
  - Human long duration mission mitigations
  - Exploration Space Suit technologies

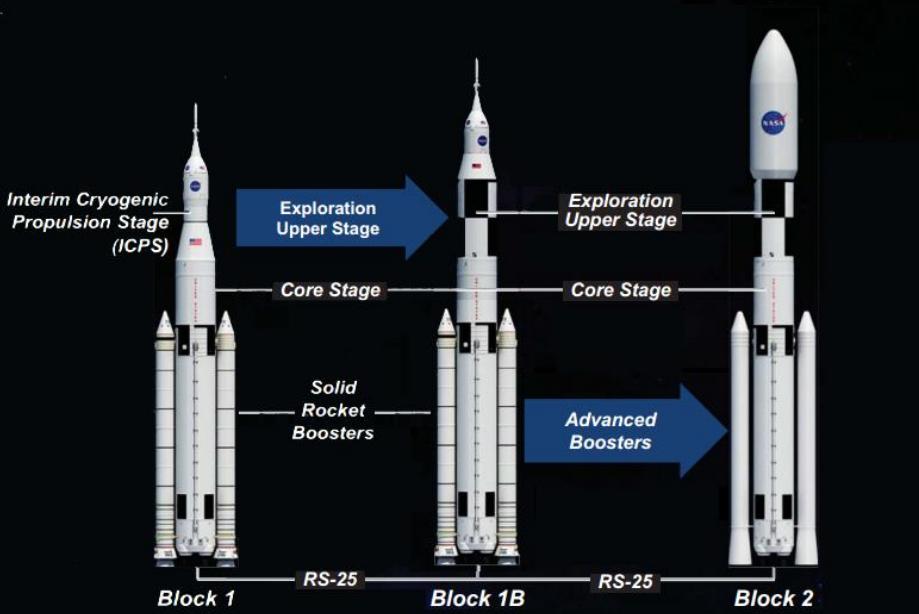


# Orion & SLS Plans



## Orion Program mission schedule

Mission	Acronym	Launch date
Exploration Flight Test 1	EFT-1	December 5, 2014
Exploration Mission 1	EM-1	November 2019
Pad Abort 2	PA-2	December 2018
Exploration Mission 2	EM-2	August 2021





# NASAs Exploration Strategy

As of March 2017

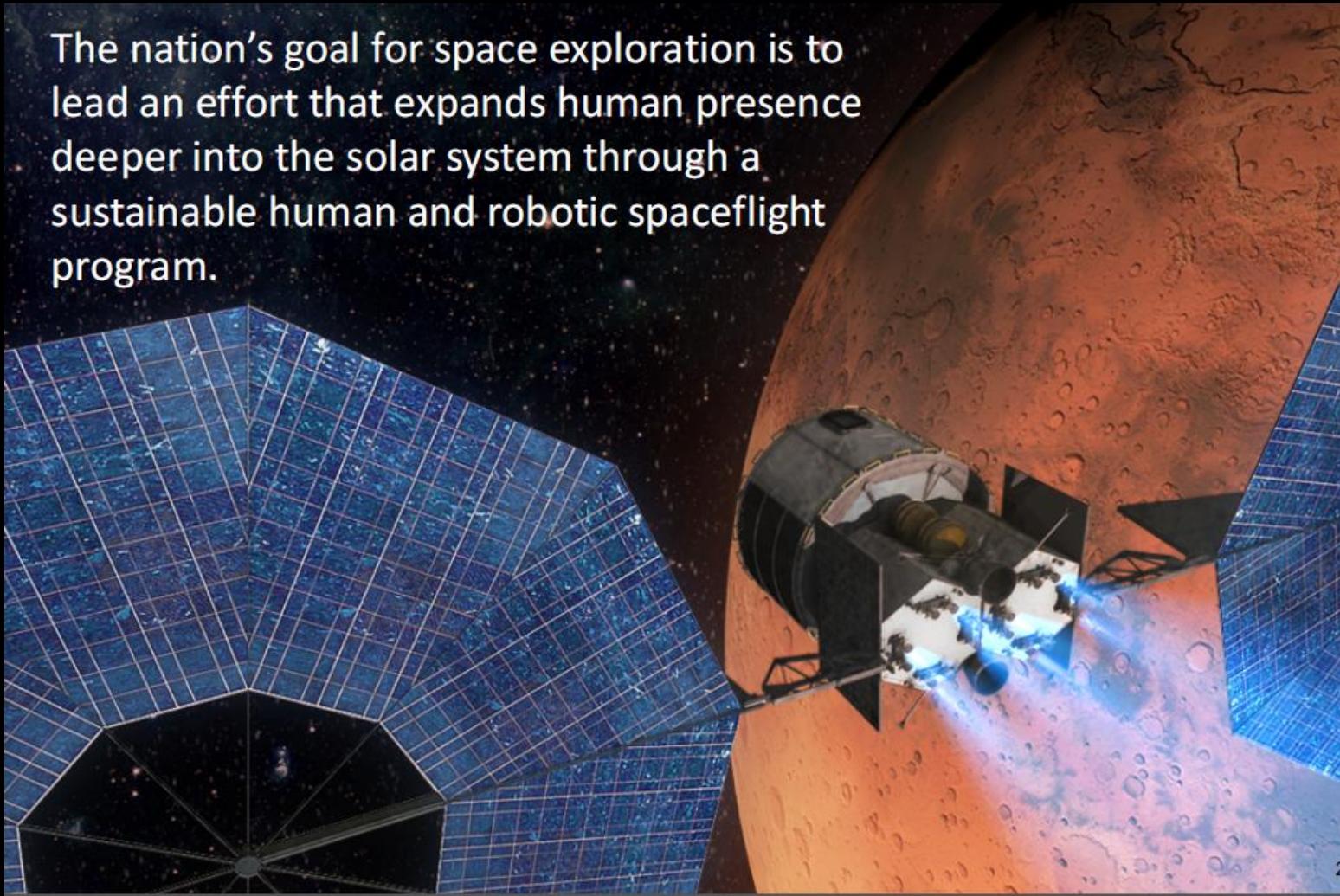
# Exploration



## Our Goal



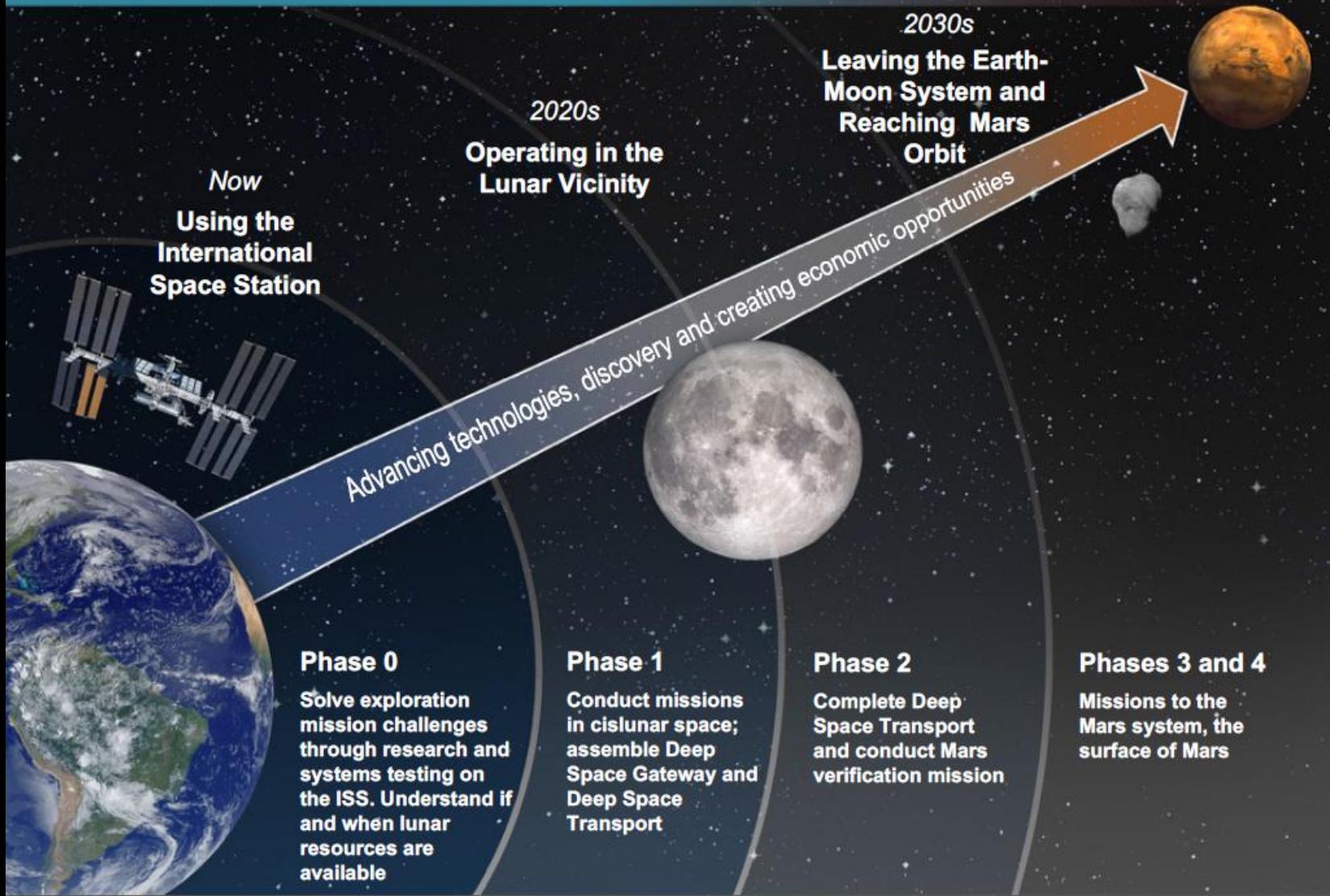
The nation's goal for space exploration is to lead an effort that expands human presence deeper into the solar system through a sustainable human and robotic spaceflight program.



# Exploration Plans



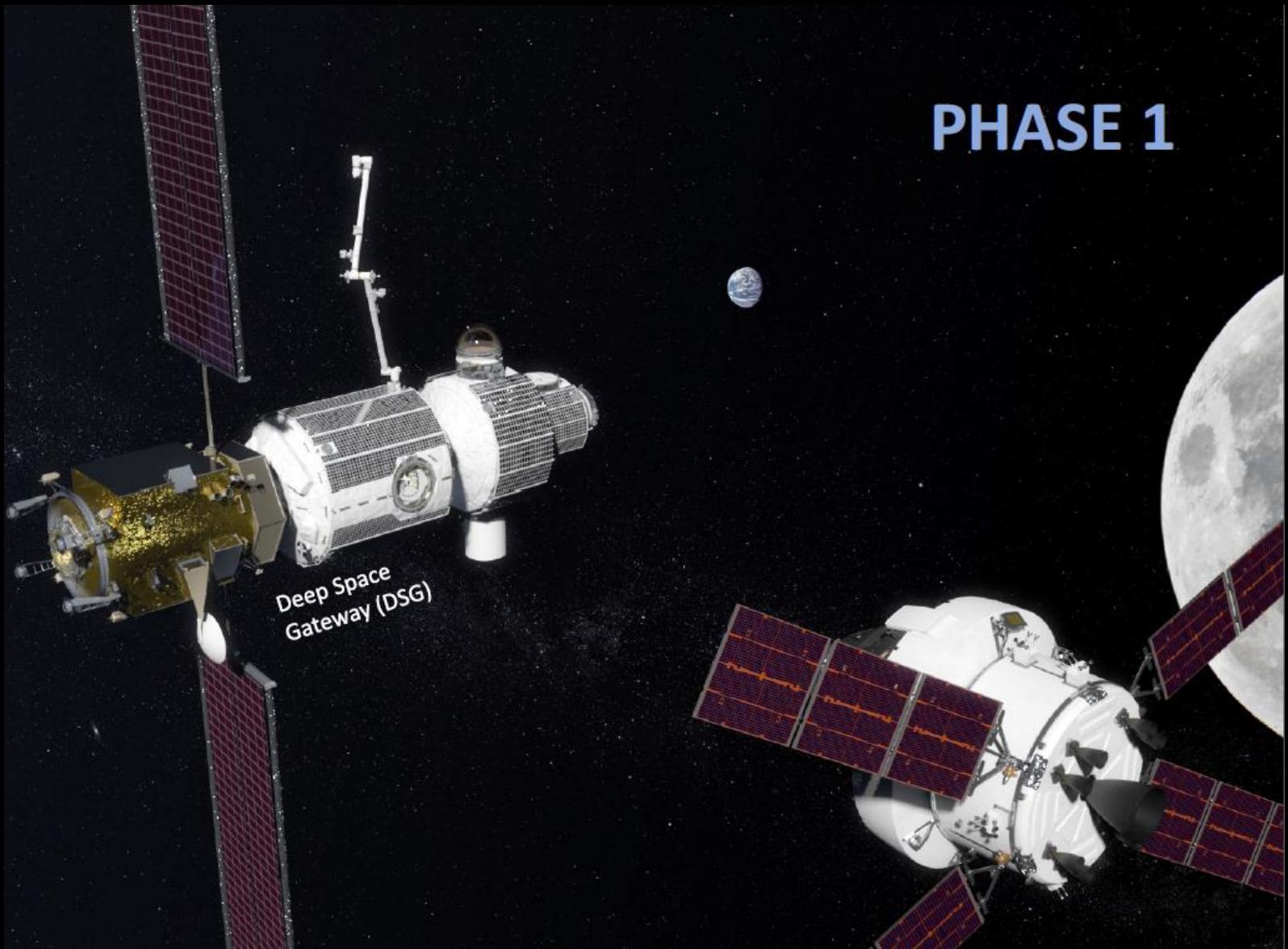
## Exploring Space In Partnership



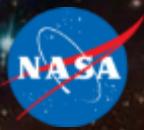
# Deep Space Gateway Functionality



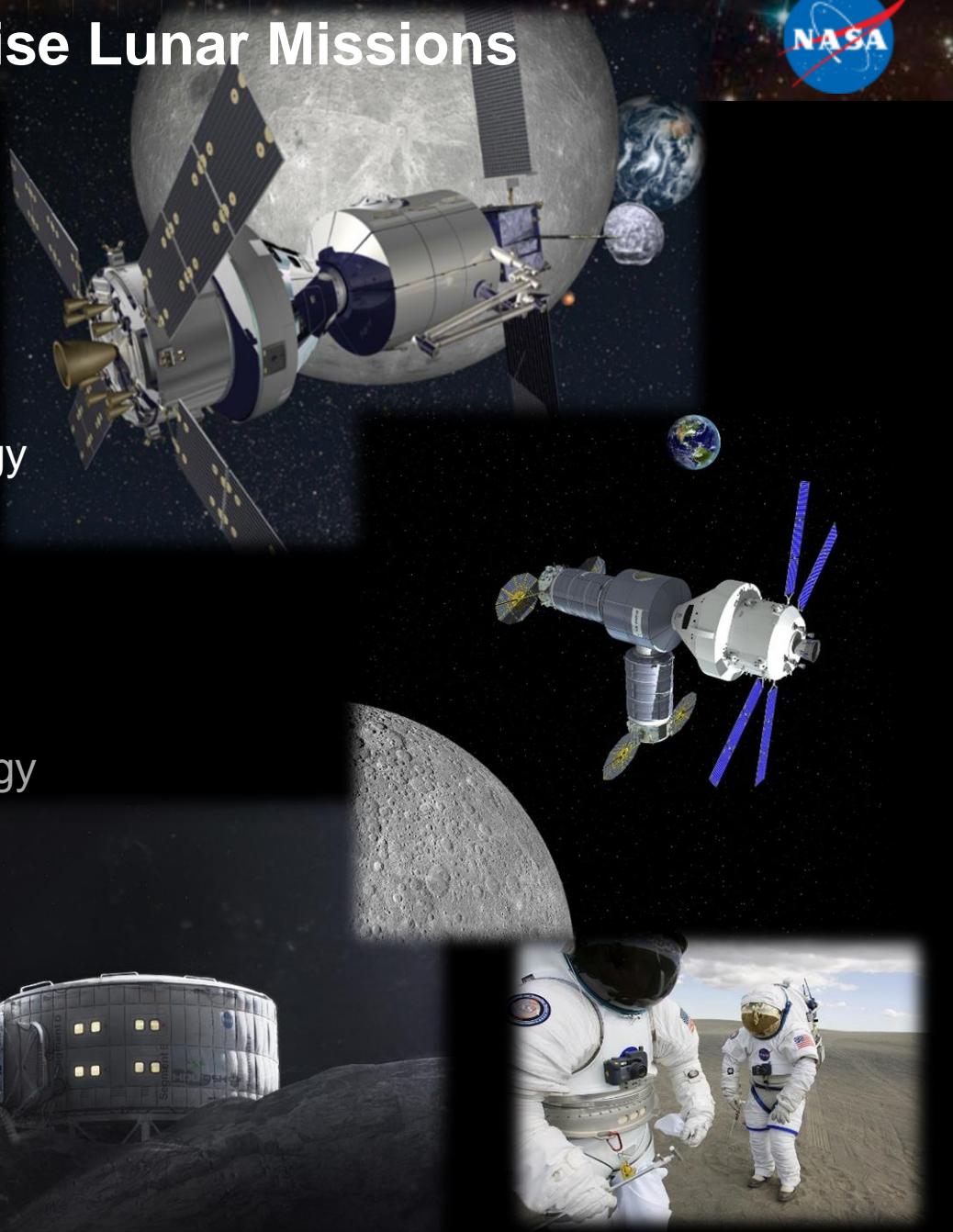
PHASE 1



# Deep Space Gateway Cise Lunar Missions



- Lunar orbiting outpost
  - Possible use of L2 (Lagrange point)
  - Science collection from deep space
  - Exploration System Technology Demonstration
- Lunar Base????
  - Science collection
  - Exploration Systems Technology Demonstration
  - Surface Habitat, Lander and Walking suit test bed for Mars

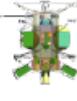
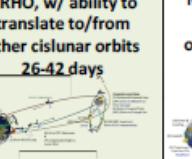
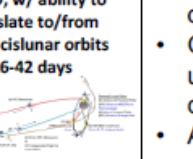
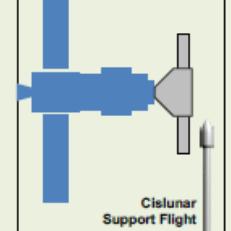
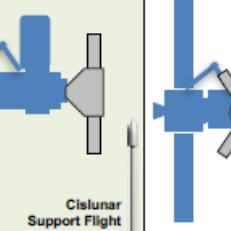
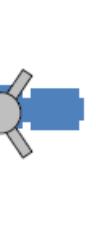


# SLS Capability and Potential Manifest



## Phase 1 Plan

Establishing deep-space leadership and preparing for Deep Space Transport development

		Deep Space Gateway Buildup					2026
EM-1	Europa Clipper	EM-2	EM-3	EM-4	EM-5		
2018 - 2025							
SLS Block 1 Crew: 0	SLS Block 1B Cargo   Europa Clipper (subject to approval)	SLS Block 1B Crew: 4 CMP Capability: 8-9T	SLS Block 1B Crew: 4 CMP Capability: 10mT	SLS Block 1B Crew: 4 CMP Capability: 10mT	SLS Block 1B Crew: 4 CPL Capability: 10mT		
		 40kW Power/Prop Bus	 Habitation	 Logistics	 Airlock		
Distant Retrograde Orbit (DRO) 26-40 days 	Jupiter Direct 	Multi-TLI Lunar Free Return 8-21 days 	Near Rectilinear Halo Orbit (NRHO) 16-26 days 	NRHO, w/ ability to translate to/from other cislunar orbits 26-42 days 	NRHO, w/ ability to translate to/from other cislunar orbits 26-42 days 		
<b>Gateway (blue) Configuration (Orion in grey)</b>			 Cislunar Support Flight	 Cislunar Support Flight			

These essential Gateway elements can support multiple U.S. and international partner objectives in Phase 1 and beyond

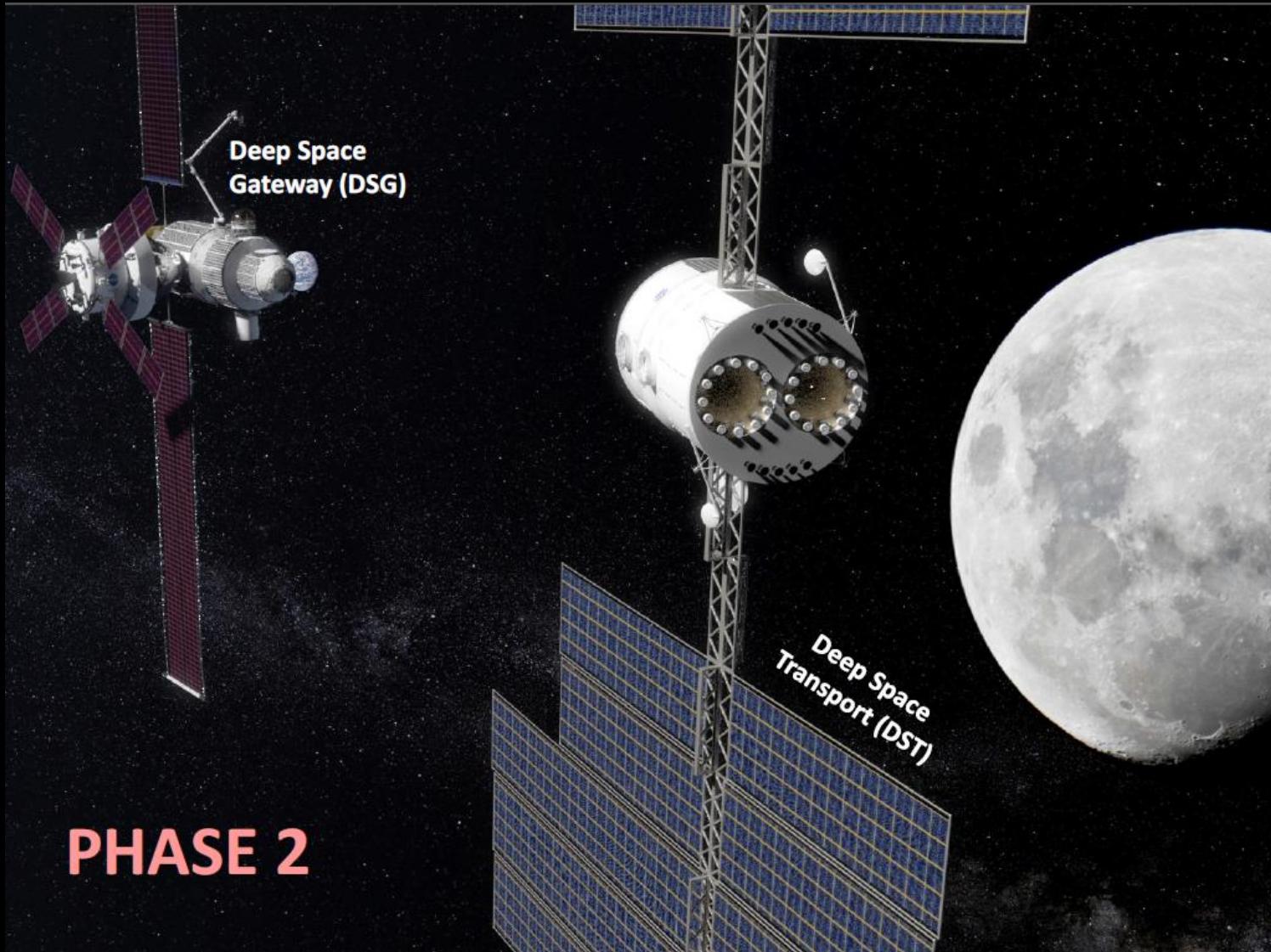
### Known Parameters:

- Gateway to architecture supports Phase 2 and beyond activities
- International and U.S. commercial development of elements and systems
- Gateway will translate uncrewed between cislunar orbits
- Ability to support science objectives in cislunar space

### Open Opportunities:

- Order of logistics flights and logistics providers
- Use of logistics modules for available volume
- Ability to support lunar surface missions

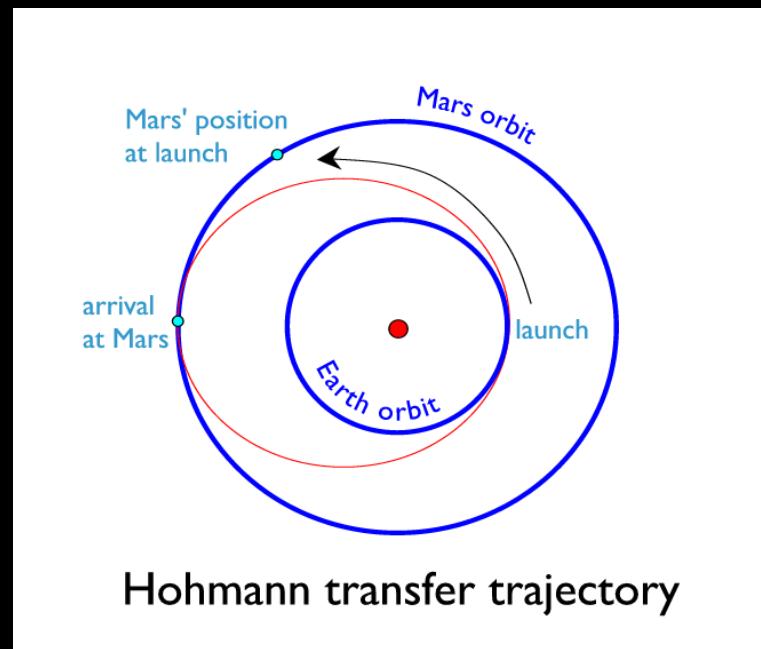
# Exploration Next Pahse



# Human Mars Mission



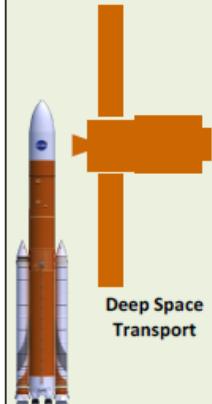
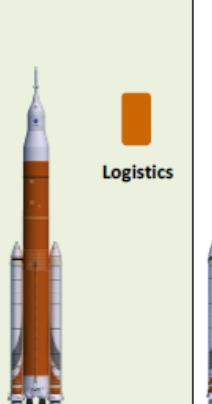
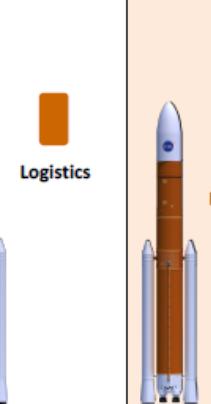
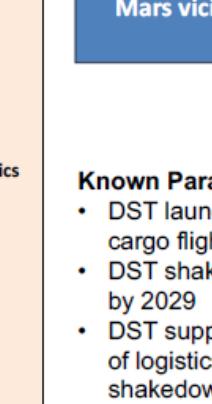
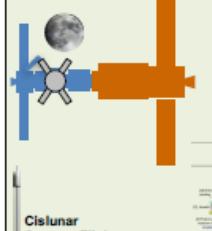
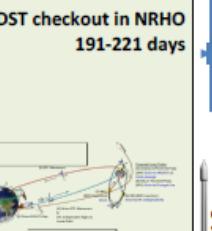
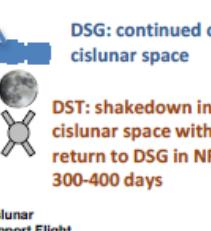
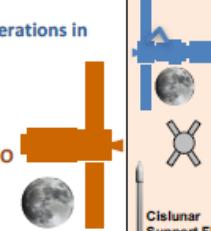
- Extend Mission Durations
- Test out Deep Space Propulsion and cargo systems
- Continue to shrink technology gap for exploration outside Earth/Moon region
- Last Phase would be a Mars transit from Deep Space Gateway



Images Credit: The Martian/20<sup>th</sup> Century Fox

## (PLANNING REFERENCE) Phase 2 and Phase 3

Looking ahead to the shakedown cruise and the first crewed missions to Mars

Transport Delivery		Transport Shakedown		Mars Transit	
EM-6	EM-7	EM-8	EM-9	EM-10	EM-11
2027		2028 / 2029		2030+	
SLS Block 1B Cargo P/L Capability: 41t TLI  Deep Space Transport	SLS Block 1B Crew: 4 CMP Capability: 10t  Logistics	SLS Block 1B Cargo P/L Capability: 41t TLI  DST Logistics & Refueling	SLS Block 2 Crew: 4 CMP Capability: 13+t  Logistics	SLS Block 2 Cargo P/L Capability: 45t TLI  DST Logistics & Refueling	SLS Block 2 Crew: 4 CMP Capability: 13+t  Logistics
 Cislunar Support Flight	DST checkout in NRHO 191-221 days 	 Cislunar Support Flight	DSG: continued operations in cislunar space 	 Cislunar Support Flight	DSG: continued operations in cislunar space  DST: Mars transit and return to DSG in NRHO 

Reusable Deep Space Transport supports repeated crewed missions to the Mars vicinity

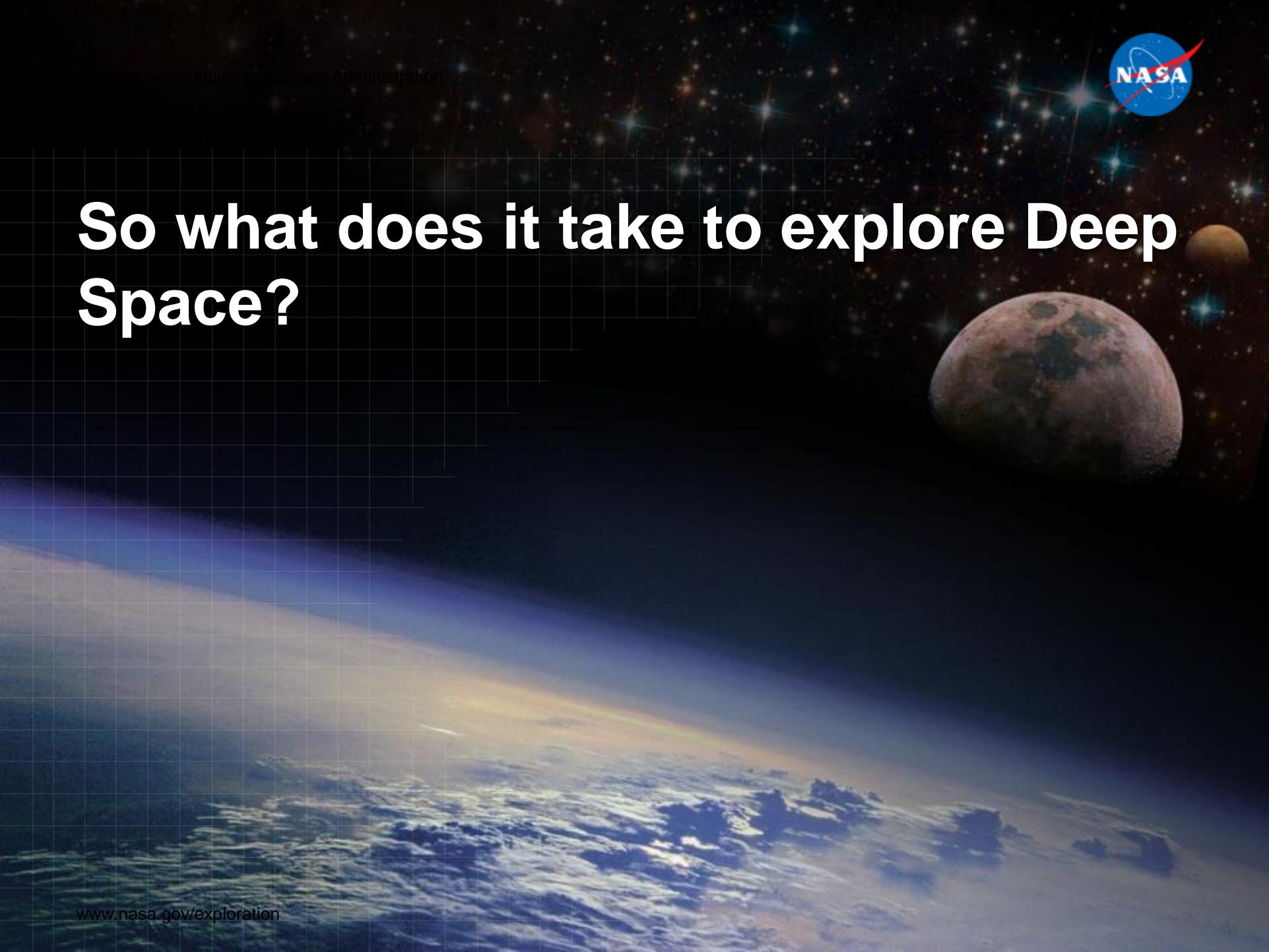
### Known Parameters:

- DST launch on one SLS cargo flight
- DST shakedown cruise by 2029
- DST supported by a mix of logistics flights for both shakedown and transit
- Ability to support science objectives in cislunar space

### Open Opportunities:

- Order of logistics flights and logistics providers
- Shakedown cruise vehicle configuration and destination/s
- Ability to support lunar surface missions

12



So what does it take to explore Deep Space?

# Space Exploration Challenges...



- Who would you need on a deep space mission?

Standard for LEO today

- Pilot
- Scientist
- Engineer

Required Systems Experts for Exploration Missions

- Propulsion
- Navigation
- Communication
- Environmental (Plumber, AC, Heat)
- Power
- Stowage/Inventory

- Other crew, required?
  - Doctor
  - Dentist
  - Psychologist
  - Geologist
  - IT/Computer
  - Machinist
  - Handyman
  - Sheriff
  - Judge/Lawyer

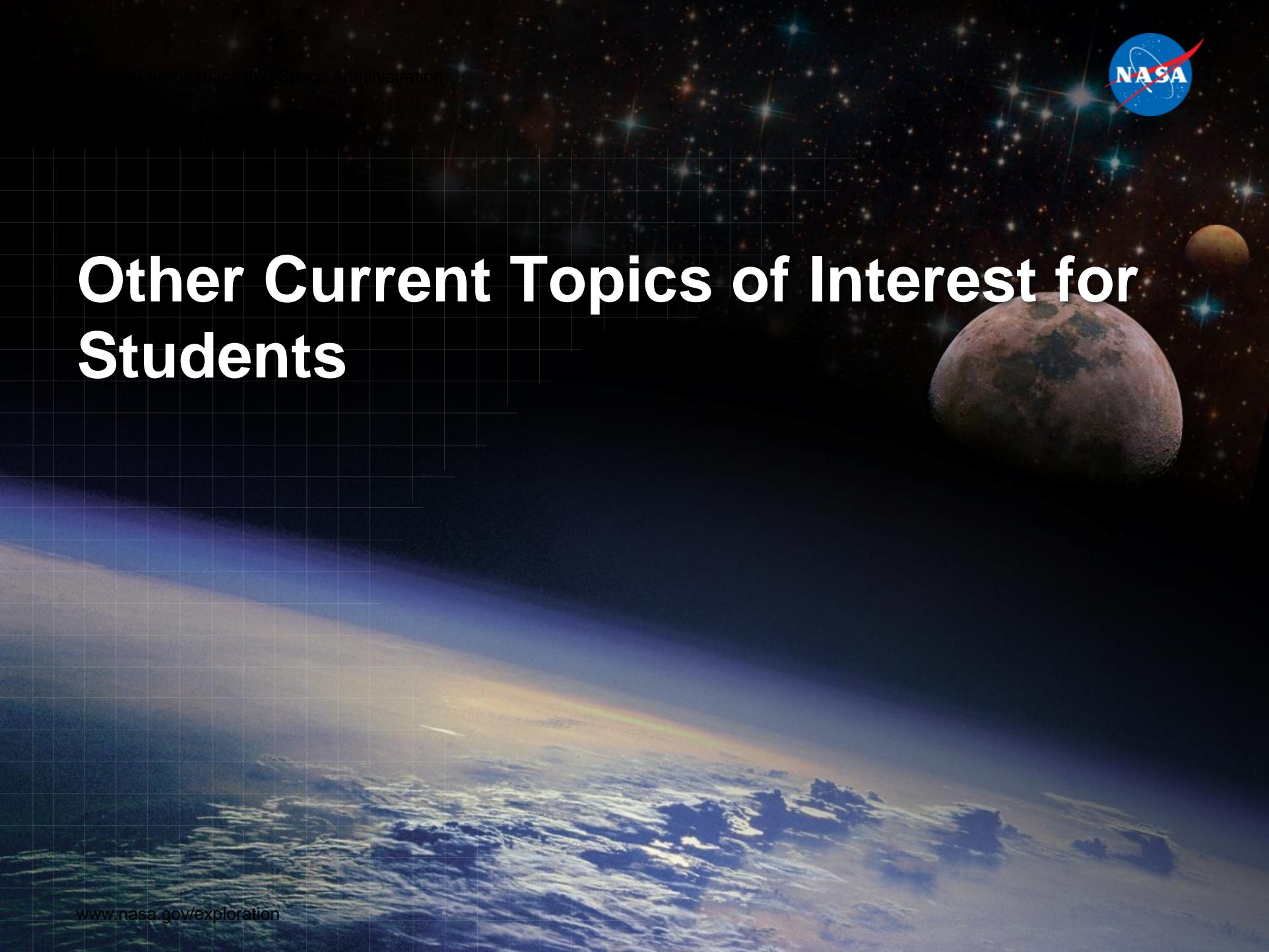
20+  
People???



# Space Exploration Challenges...



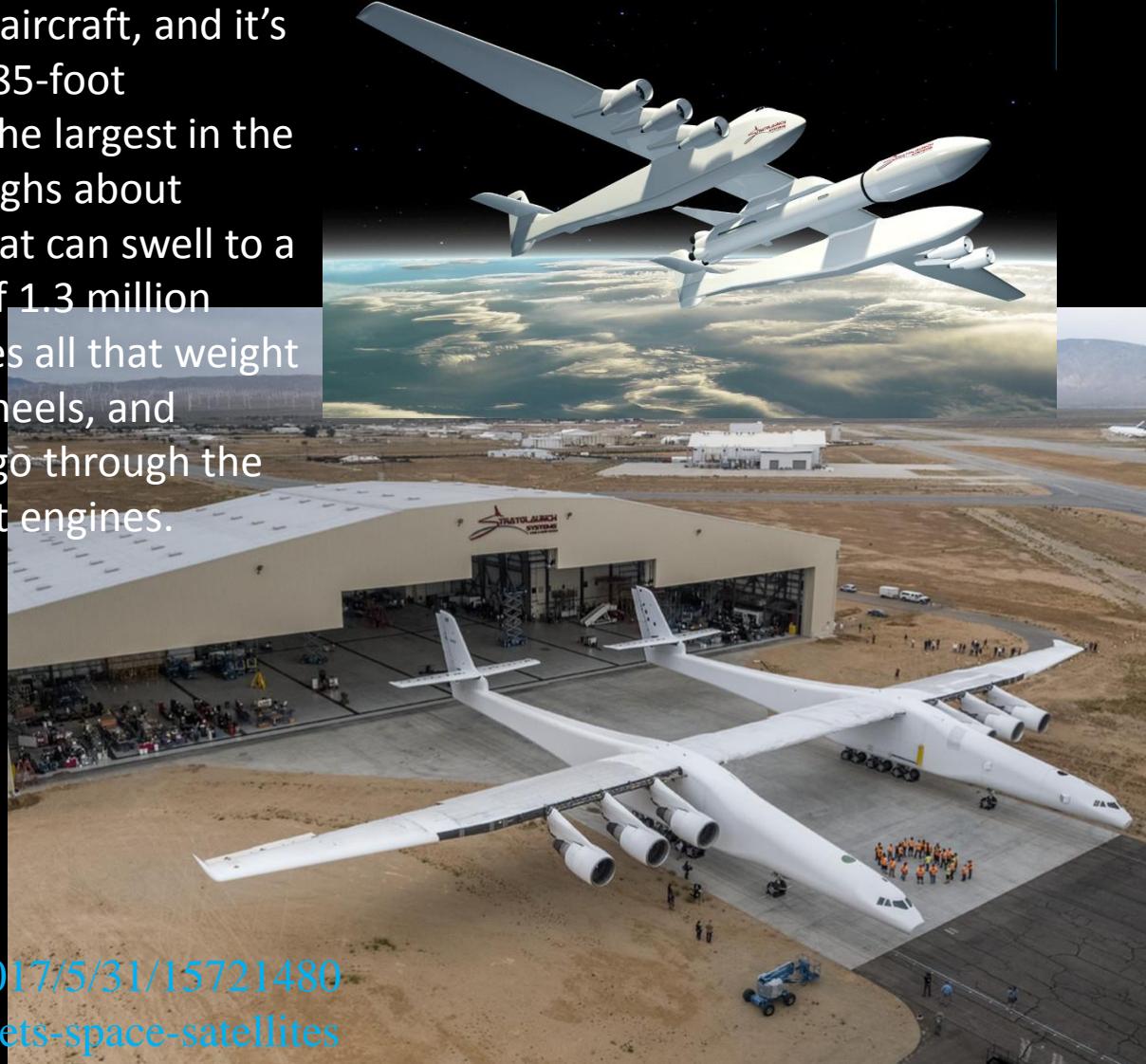
- Up mass
  - Exploration Vehicle – est. 100 tons of material and supplies (ISS 420 tons)
- Propulsion
  - Chemical, Ion, Solar Electric
- Environmental Systems
  - Closed loop, Reliability, Redundancy
- Automation
  - Self maintaining systems
- Radiation Shielding
  - Crew and systems health
- Communication
  - Comm delays increase
- Long Range Human Health Affects
  - Bone health, eye damage, long term radiation exposure
- Stowage/Logistics



# Other Current Topics of Interest for Students

# Stratolaunch - Microsoft co-founder built the world's largest plane to launch rockets into space

It's called the Stratolaunch aircraft, and it's massive. The plane has a 385-foot wingspan, which makes it the largest in the world by that metric. It weighs about 500,000 pounds dry, but that can swell to a maximum takeoff weight of 1.3 million pounds. Stratolaunch moves all that weight across the ground on 28 wheels, and eventually will carry its cargo through the air thanks to six 747 aircraft engines.



<https://www.theverge.com/2017/5/31/15721480/stratolaunch-paul-allen-rockets-space-satellites>

# First Private Moon Landing Gears Up for Launch by Year's End



Moon Express and Rocket Lab are poised to make history.

Moon Express (or MoonEx), a space exploration company powered by industry engineers and Silicon Valley money, is making the final adjustments to its lunar lander in its facilities at Cape Canaveral. Its goal is to achieve something that has only been accomplished by the three largest superpowers in the world: a soft landing on the moon.

"It will be the space equivalent of the four-minute mile. I think we're going to redefine the possible," MoonEx co-founder and CEO Bob Richards tells *Popular Mechanics*. "We've seen this throughout history—everybody thinks something is impossible until they see it done."



<http://www.popularmechanics.com/space/moon-mars/a26702/moon-express-lunar-landing-launch-years-end/>

# Blue Origin Rides into Space

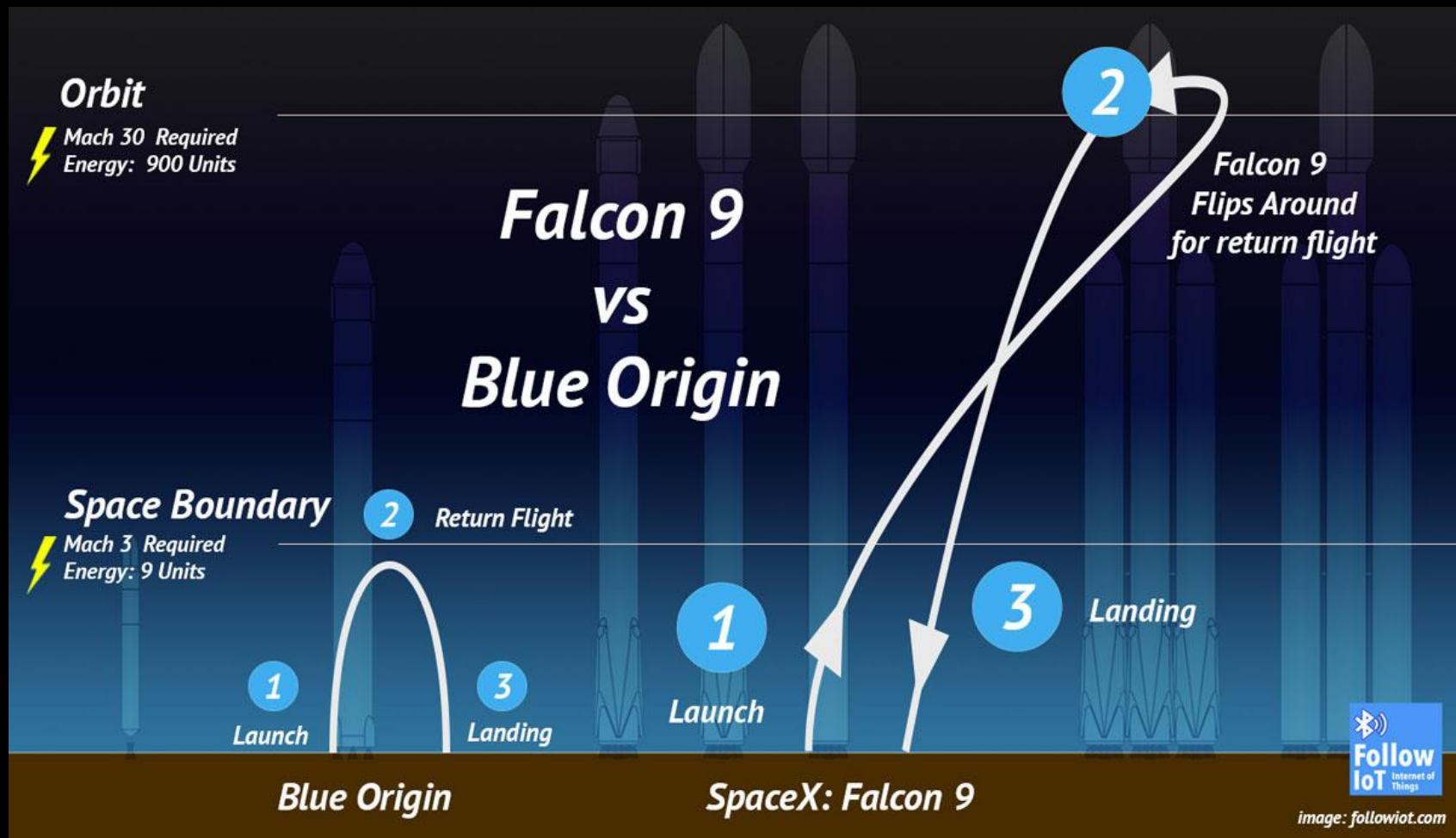


Blue Origin released new images today (March 29) of the interior of its New Shepard passenger capsule, which the company says will be used to send paying customers on brief trips into space.



<https://www.space.com/36267-blue-origin-space-capsule-interior-sneak-peek.html>

# Interesting Look at Blue Origin vs SpaceX





# Questions?

# Thank You!



My favorites...

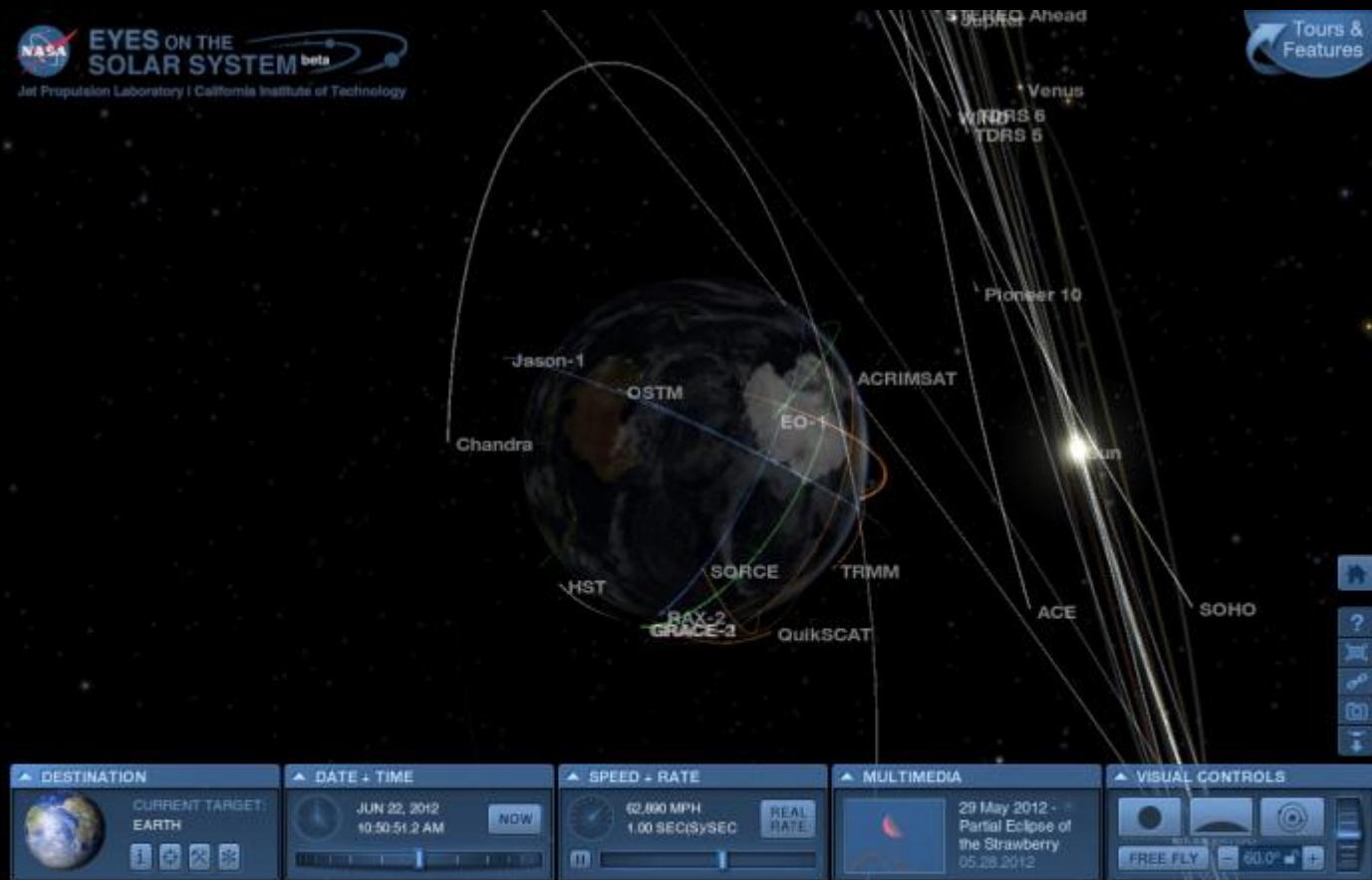
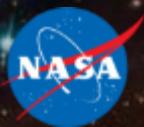


# My favorite sites and links...

- Heavens Above
  - <http://heavens-above.com/>
- NASA Spinoffs
  - <http://spinoff.nasa.gov/>
- Eyes on the Solar System
  - <http://eyes.nasa.gov/>
  - Youtube NASA Television
  - <http://www.youtube.com/user/NASAtlevision>
  - Youtube Earth Video
  - <http://www.youtube.com/watch?v=lp2ZGND1I9Q>
  - ISS Tour by CDR/Suni Williams
  - <http://www.youtube.com/watch?v=doN4t5NKW-k>
  - Why Mars is Hard Stan Love
  - <http://www.youtube.com/watch?v=fturU0u5KJo>
- Perspectives
  - <http://htwins.net/scale2/?bordercolor=white>
- ISSLive
  - <http://spacestationlive.jsc.nasa.gov/>
- Distance Learning Network
  - NASA DLN Website: <http://www.nasa.gov/offices/education/programs/national/dln/index.html>
  - Toolkit with Material and Templates:  
<http://communications.nasa.gov/OCP/Communications%20Tool%20Kit/Presentation%20Templates/Web%20Sites/CTK.html>



# JPL – Eyes on the Solar System

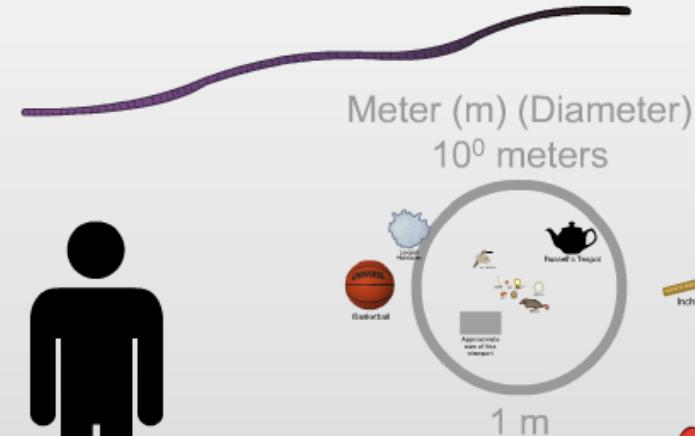


Eyes on the Solar System  
<http://eyes.nasa.gov/>

<http://htwins.net/scale2/?bordercolor=white>

♪ Q

## Giant Earthworm



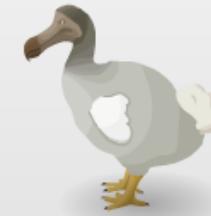
Human



Rafflesia



Beach ball



Dodo Bird

10<sup>0.0</sup>

Copyright © 2012 Cary and Michael Huang (<http://htwins.net>)

Other languages

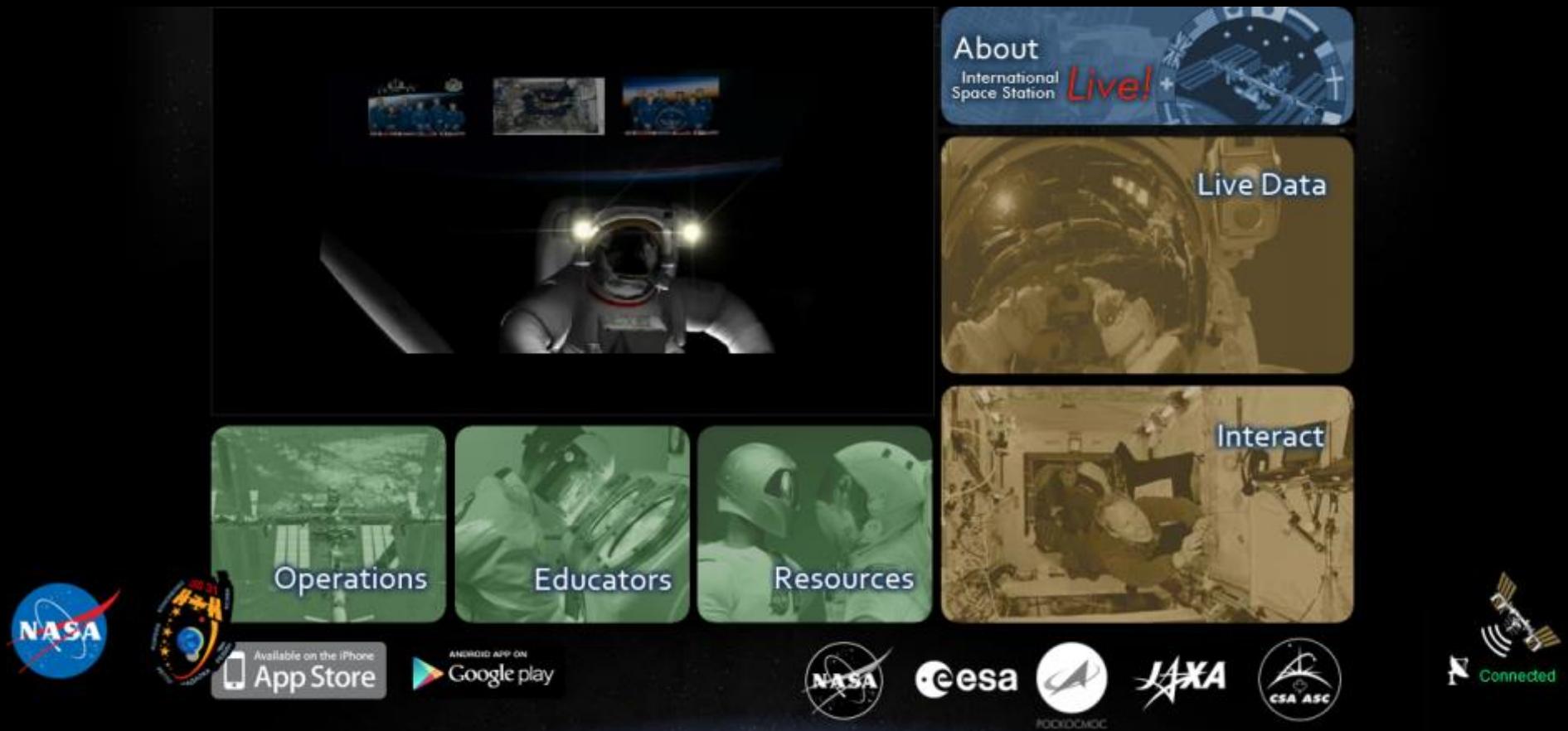
Back

# ISSLive



## ISSLive

<http://isslive.com/>



The image shows the ISSLive website. At the top, there is a large banner with a space-themed background featuring stars and a satellite. The NASA logo is in the top right corner. The main content area has a dark background with several video feeds and text labels. In the top left, there are three small video thumbnails. In the center, a large video feed shows an astronaut inside the International Space Station. To the right, there are three more video feeds: one labeled 'About International Space Station Live!', one labeled 'Live Data' showing a close-up of a satellite, and one labeled 'Interact' showing an astronaut working on a experiment. Below these, there are three green-tinted video feeds labeled 'Operations', 'Educators', and 'Resources'. At the bottom, there are download links for the 'App Store' and 'Google play', and logos for NASA, ESA, Roscosmos, JAXA, and CSA ASC. A small icon of a satellite with a signal is in the bottom right corner.

Operations

Educators

Resources

Available on the iPhone  
App Store

ANDROID APP ON  
Google play

NASA

esa

ROSCOMMOS

JAXA

CSA ASC

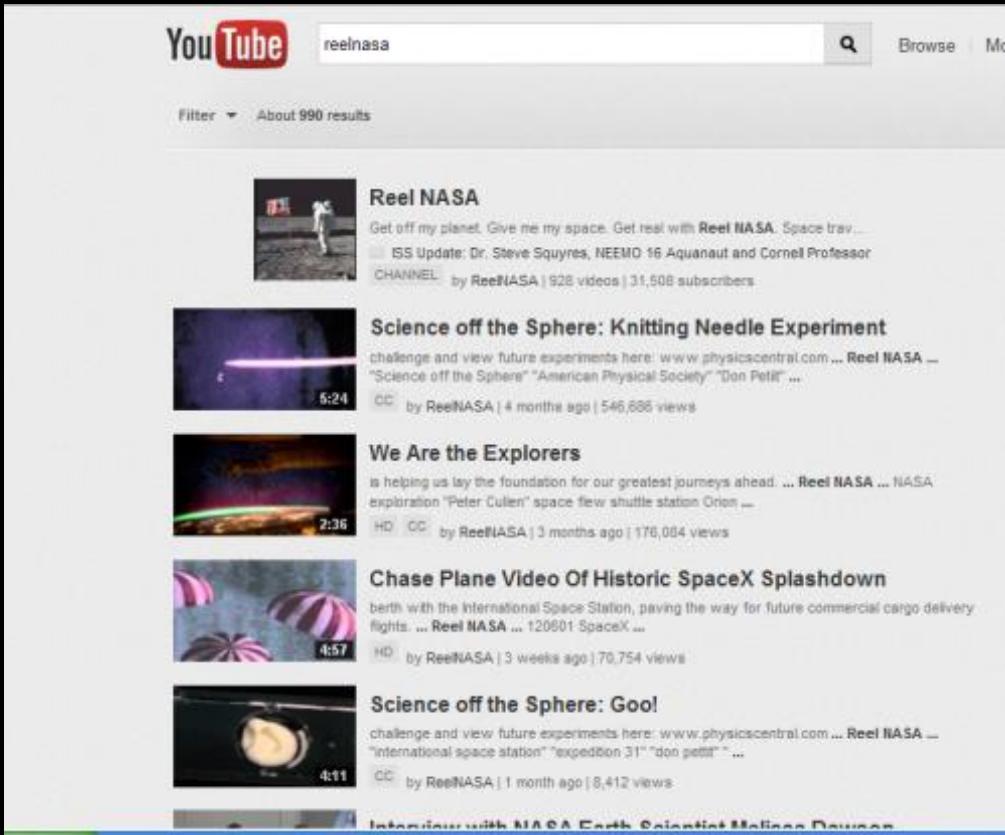
Connected

# Youtube – REELNASA



## ReelNASA

[http://www.youtube.com/results?search\\_query=reelnasa&sa=X&spell=1&search=Search&oi=spell](http://www.youtube.com/results?search_query=reelnasa&sa=X&spell=1&search=Search&oi=spell)



YouTube search results for "reelnasa" showing 990 results. The results include:

- Reel NASA**  
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ISS Update: Dr. Steve Squyres, NEEMO 16 Aquanaut and Cornell Professor  
CHANNEL by ReelNASA | 928 videos | 31,508 subscribers
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berth with the International Space Station, paving the way for future commercial cargo delivery flights. ... Reel NASA ... 120801 SpaceX ...  
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# Heavens Above



<http://heavens-above.com/>

**Heavens-Above Home Page - Windows Internet Explorer**

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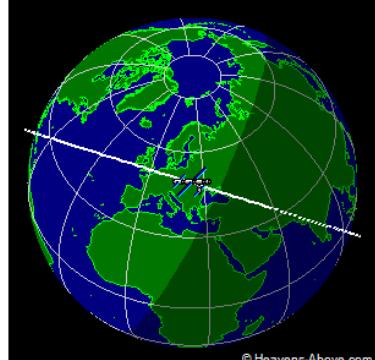
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**Configuration**  
Current observing site: **Clear Lake, 33.0781°N, 96.4950°W**  
select from map or [from database](#) or [edit manually](#)  
Registered user login | Why register?  
[Create new user account](#)

**Satellites**  
10 day predictions for: [ISS](#) | [Tiangong 1](#)  
[Genesis-1](#) | [2](#) | [Envisat](#) | [HST](#)  
Select another satellite from the database  
Daily predictions for all satellites brighter than magnitude:  
(brightest) [3.5](#) | [4.0](#) | [4.5](#) (dimmest)  
All passes of [ISS](#) - including daylight and invisible passes.  
Iridium Flares  
[next 24 hrs](#) | [next 7 days](#) | [previous 48 hrs](#)  
Daytime flares for 7 days - see satellites in broad daylight!  
Spacecraft escaping the Solar System - where are they now?  
Radio amateur satellites - 24 hour predictions (all passes)  
Height of the ISS | Phobos Grunt - how does it vary with time

**Astronomy**  
Comets currently brighter than mag. 12  
[189P NEAT](#) | [96P Machholz](#) | [C/2009 P1 Garradd](#)  
Minor planets currently brighter than mag. 10  
[4 Vesta](#) | [1 Ceres](#) | [18 Melpomene](#)  
Whole sky chart  
Sun and Moon data for today  
Planet summary data  
Planet details (under construction)  
[Mercury](#) | [Venus](#) | [Earth](#) | [Mars](#) | [Jupiter](#) | [Saturn](#) | [Uranus](#) | [Neptune](#) | [Pluto](#)  
Solar system chart

**Current position of ISS**



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# NASA Distance Learning



NASA DLN Website: <http://www.nasa.gov/offices/education/programs/national/dln/index.html>

The screenshot shows the homepage of the NASA Digital Learning Network (DLN). The top navigation bar includes links for HOME, NEWS, MISSIONS, MULTIMEDIA, CONNECT, and ABOUT NASA. A search bar is also present. The main content area features a banner for the DLN with the text "NASA Digital Learning Network™" and "DLN sites: Ames, Dryden, Glenn, Goddard, JPL, Johnson, Kennedy, Langley, Marshall, Stennis" and "A Universe of Possibilities". Below the banner, a section titled "Welcome to NASA's DLN" provides information about the network's purpose and encourages users to register for events or watch webcasts. It includes social media links for Facebook and Twitter. A video thumbnail on the right shows a classroom setting. The left sidebar contains a list of links for DLN Home, About DLN, Event Catalog, PD & Special Events, Event Guidelines, DLInfo Channel, Technical FAQ, 5E Teaching Model, Tools & Plugins, Contact Us, Feedback Forms, and Search Event. The bottom sidebar includes a "DLN User" section with links for Sign In, New User Registration, New School/Org Registration, and Forgot Password, as well as a "DLN Announcements" section.

NASA DLN Website: <http://www.nasa.gov/offices/education/programs/national/dln/index.html>

**DLN** NASA Digital Learning Network™  
DLN sites: Ames, Dryden, Glenn, Goddard, JPL, Johnson, Kennedy, Langley, Marshall, Stennis  
A Universe of Possibilities

Welcome to NASA's DLN

NASA's Digital Learning Network™ provides science, technology, engineering, and mathematics or STEM content featuring NASA missions and research. Register for free, interactive events listed in our catalog or watch our webcasts listed below.

[Like us on Facebook!](#)  
[Follow us on Twitter!](#)

To assist both new and existing users, we **STRONGLY** encourage you to view our [DLN Overview Video](#) and the [DLINtro presentation](#) located in [About DLN](#). DLINtro will guide you through our website, show how to register for modules, and explain other services.

**DLN User**

- > Sign In
- > New User Registration
- > New School/Org Registration
- > Forgot Password

**DLN Announcements**

USDLA Awards NASA's Digital Learning

See the Space Station fly over YOUR home!

Use "Skywatch" program or go to "sightings by city"

- [spaceflight.nasa.gov/reldata/sightings](http://spaceflight.nasa.gov/reldata/sightings)

SATELLITE	LOCAL DATE/TIME	DURATION (MIN)	MAX ELEV (DEG)	APPROACH (DEG-DIR)	DEPARTURE (DEG-DIR)
ISS	Tue Nov 14/06:22 AM	4	66	10 above WSW	31 above NE

